The Predator-Prey Relationship between the Octopus (*Octopus bimaculatus*) and the California Scorpionfish (*Scorpaena guttata*)[1]

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ABSTRACT: The predator-prey relationships between the California scorpionfish *Scorpaena guttata* Girard and the octopus *Octopus bimaculatus* Verrill were examined by observations of behavior in aquariums. California scorpionfish eat small octopuses, but they specifically evade large octopuses attempting to stalk them, in contrast with their defensive behavior, employing the venomous spines, against other potential predators. They appear to discriminate between predatory behavior and other kinds of behavior of octopuses. The observations suggest that, in nature, octopuses prey on scorpionfish, principally on the juveniles.

CALIFORNIA SCORPIONFISH, *Scorpaena guttata* Girard, bear venomous dorsal, ventral, and anal spines (Halstead, Chitwood, and Modglin, 1955) which inflict extremely painful stings and can be injurious to humans (Halstead, 1951). The fish gained wide notoriety from reports of stings received by "aquanauts" from scorpionfish attracted to the U. S. Navy's "Sealab II" (Clarke, Flechsig, and Grigg, 1967: 1383–1384, 1387).

Since the venomous spines probably were not evolved as a defense against humans, and since they are not used in capturing prey, what is their natural function? They probably serve as protection against predators—larger fishes, seals, sea lions, and dolphins are possibilities. Direct evidence from nature is lacking, but aquarium observations support this function (Taylor, 1963: 93, 101–106). Clarke, Flechsig, and Grigg (1967:1387) noted the lack of predation on scorpionfish at "Sealab II" in spite of frequent presence of California sea lions (*Zalophus californicus*), which are known to eat other scorpaenid fishes (Arthur L. Kelley, personal communication).

An incident observed in the Aquarium-Museum at the Scripps Institution of Oceanography suggested that large octopuses may be predators on the California scorpionfish (Taylor, 1963:105–106). An octopus, *Octopus bimaculatus* Verrill, quickly captured and ate one of 23 California scorpionfish introduced into a display tank occupied by two octopuses. The second octopus repeatedly stalked other scorpionfish. They avoided its advances by swimming away, in distinct contrast to their behavior toward other potential predators, as will be discussed later.

The California scorpionfish lacks a swim bladder and is bottom-dwelling, as is the octopus *Octopus bimaculatus*. In nature they are usually found among rocks, in crevices or caves, or near other features providing cover. Both species are often found in close proximity in these habitats, making encounters between them likely. The investigation reported here explored the predator-prey relationships between the two species.

MATERIALS AND METHODS

Most of the observations were made in San Diego, California, during the summer of 1967, using facilities of the Sea World Aquarium and of the Aquarium-Museum of the Scripps Institution of Oceanography. Display tanks with animals and habitats (rockwork, seaweeds, etc.) already established were employed for some ob-

[1] Supported by Office of Naval Research Contract N0014-67-0390, awarded to Dr. Findlay E. Russell, University of Southern California School of Medicine, Los Angeles, California. Contribution No. 492 from the Department of Oceanography, University of Washington, and a contribution from the Scripps Institution of Oceanography. Manuscript received August 14, 1968.

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servations. Habitats and animals were manipulated in other tanks placed at our disposal at Sea World.

Specimens of California scorpionfish, *Scorpaena guttata* Girard, were collected from various locations along the coast at San Diego. Octopuses, *Octopus bimaculatus* Verrill, were collected intertidally and in subtidal water. Most of the observations were made on this species, and subsequent mention of octopuses will be of this species unless otherwise specified. *Octopus dofleini* (Wülker) specimens were shipped from Seattle, Washington. They were used for some observations because of their exceptionally large sizes.

OBSERVATIONS

Habitat Selection

In aquarium habitats, resting octopuses usually stay under rocks, in crevices, or in cavelike locations wherever available in the tanks. When more than one octopus was present they often engaged in territorial fighting. As a result, the rocky habitats became saturated and unsuccessful individuals were driven into open areas. In the large tank shown in Figure 1, we had up to five octopuses. Three of these, after much fighting, occupied the rock caves. The other two competed for one rock in the front, and both were seen often in open areas. The larger individuals generally dominated the smaller ones.

In aquariums without octopuses the California scorpionfish usually positioned themselves among the rocks, against a side of the tank, or against each other. There was no aggressiveness between individuals.

California scorpionfish and octopuses placed together in a tank were always separated by objects or by some distance—they were never in contact. Censuses were made in the large reserve tank to note the relative positions of these animals. Some typical arrangements are shown in Figure 1. Note that the scorpionfish and octopuses can persist in close proximity to each other, but the behavioral interactions of the two species, described later, maintained finite distances between them. More scorpionfish were seen away from the cover of rocks when octopuses were present than when they were absent.

The introduction of scorpionfish into a tank containing two or more octopuses appeared to stimulate fighting between the latter. This was perhaps competition for potential prey.

Successful Captures by Octopuses

Seven observations of octopuses capturing California scorpionfish, including the incident previously mentioned, are listed in Table 1. An

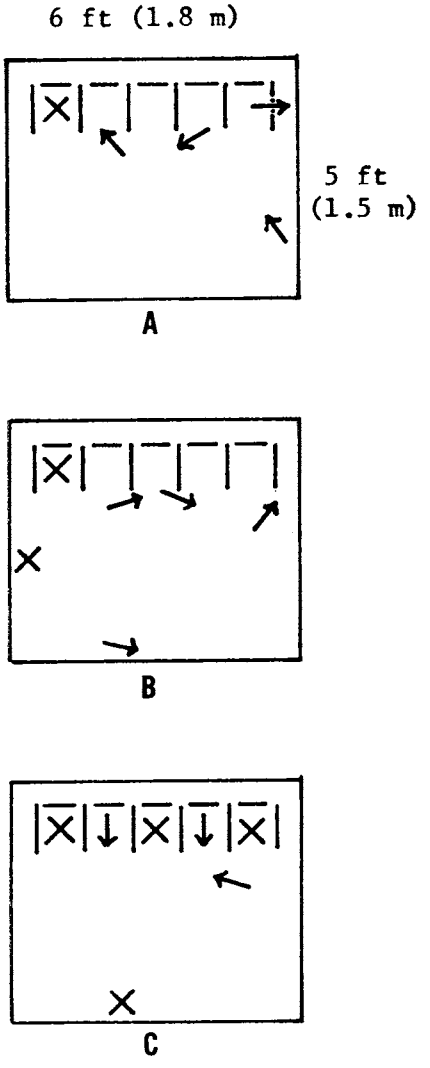

FIG. 1. Positions of California scorpionfish and octopuses in tank trials. A, Octopus introduced two minutes earlier; nearest scorpionfish displaced from cave. B, Octopuses active; scorpionfish driven into open. C, Octopuses inactive; scorpionfish and octopuses occupy adjacent caves. Symbols: →, scorpionfish: ×, octopus; ⊓, cave of stacked boulders.

TABLE 1

SUCCESSFUL CAPTURES OF CALIFORNIA SCORPIONFISH BY OCTOPUSES
(most sizes based on visual estimates)

OBSERVATION NO.	OCTOPUS		CALIFORNIA SCORPIONFISH	
	Species	Arm Spread	Length	Action
1	*O. bimaculatus*	100 cm	33 cm	Seized, partly eaten
2	*O. bimaculatus*	35 cm	11 cm	Seized while restrained, partly eaten
3	*O. bimaculatus*	50 cm	25 cm	Seized while restrained, partly eaten
4	*O. bimaculatus*	40 cm	7 cm	Seized, completely eaten
5	*O. bimaculatus*	40 cm	5 cm	Seized, completely eaten (same octopus as No. 4)
6	*O. dofleini*	2 m	30 cm	Seized, later released unharmed
7	*O. dofleini*	1 ½ m	26 cm	Seized, completely eaten

octopus can subdue a relatively large scorpionfish, but in all such cases it is possible to cite circumstances favoring the octopus. Referring to the observation numbers in Table 1, these circumstances were as follows:

1. Twenty-three scorpionfish were introduced into a large tank already containing two octopuses. The scorpionfish were probably disoriented from being introduced into the tank.

2 and 3. The scorpionfish were restrained within reach of the octopus by means of a dipnet.

4 and 5. The scorpionfish were much smaller than the octopus and were confined in an area too small for escape from it. The aquarium tank was 24 inches (61 cm) by 12 inches (30 cm) by 12 inches (30 cm) deep.

6 and 7. Same as 4 and 5 except that the tank measured approximately 6 feet (1.8 m) by 5 feet (1.5 m) by 3 feet (0.92 m) deep.

An octopus captures a scorpionfish by attaching two or more arms along the fish's body, hauling it toward the horny beak, and enveloping it with more arms and the web. Although difficult to see, the fish's spines are erected but do not affect the octopus. They probably do not puncture the octopus because of its pliability. The fins and spines of intact or partly eaten fish released by octopuses showed no evidence of damage which would indicate that they had punctured their captors.

We have seen no evidence that the octopuses use venom in subduing scorpionfish as they do for crustaceans and mollusks (Ghiretti, 1960; Pilson and Taylor, 1961). In both observations on *O. dofleini* (Table 1), the scorpionfish could be seen moving their opercula in regular respiratory movements and struggling in occasional bursts over periods up to 30 minutes after capture.

The "partly eaten" scorpionfish of Table 1 lacked the viscera, but most of the trunk musculature remained. The head and fins were left intact. Only the trunk skeleton, head, and fins remained of fish that were "totally consumed."

One field observation provides further evidence of the predatory role of the octopus. Mr. Robert Kiwala (personal communication), marine collector for the Scripps Institution, found in the mouth of a cave in a clay ledge of La Jolla (submarine) Canyon a dead, partly eaten scorpionfish, estimated 35 cm total length. The cave contained a large octopus, which he estimated was 60 cm in arm spread and was probably *Octopus bimaculatus*. Presumably, although not certainly, the octopus had captured the scorpionfish. We have observed many octopuses (*O. bimaculata*) and scorpionfish while diving along the same clay ledge, indicating the high probability of encounters between them.

Responses of California Scorpionfish to Octopuses

A California scorpionfish approached threateningly by a large fish or a SCUBA diver will

often stand fast, adopting a defensive posture. The venomous spines invariably are erected. With more extreme harassment the body becomes somewhat inclined head downward, and the fish may turn to direct its dorsal spines toward the intruder. Contrasting with this behavior, scorpionfish evade octopuses rather than standing fast. The fish react quickly to remain out of reach, especially of octopuses stalking them. Scorpionfish seem, in fact, to discriminate between kinds of octopus behavior. An octopus attempting to stalk prey has a distinctive behavior. It moves stealthily, approaching the potential prey without sudden movements, and assumes a characteristic posture with the head held high and the arms curled compactly underneath (Fig. 2). The fish remain alert to an octopus behaving this way, always swimming to stay out of reach. The fish are less responsive to octopuses behaving with indifference to them. For example, we observed several times that octopuses fighting with each other bump into scorpionfish without causing vigorous responses from the fish. Furthermore, scorpionfish reacted only mildly to octopuses that, disturbed by bright light used for photography, moved erratically about the tank with arms extended and waving. The fish were indifferent to an octopus which was restrained in a plastic container with holes that allowed extension of its arms.

Scorpionfish were quick to escape lunging movements made by octopuses at close quarters. In fact, scorpionfish escaped lunges at distances shorter than the arm lengths of the octopuses (the arms are usually coiled under for the attack). Even when an octopus was on the opposite side of a rock, a scorpionfish responded quickly to arms extended under or around the rock. Possibly the fish sensed sudden movements in the water by the lateral line system as well as visually, since it was not always certain that the attacking arm was within sight. The responses of one blinded fish were examined from this point of view. The fish responded to an octopus only when contacted. It escaped capture only by being large enough to thrash loose. This one observation is inconclusive but supports the importance of vision.

In another attempt to evaluate the role of vision, we enclosed the animals together in small tanks darkened by lightproof covers. In a tank 30 inches (76 cm) by 24 inches (61 cm) by 24 inches (61 cm) deep, a scorpionfish approximately 15 cm in total length and an octopus with approximately 40 cm arm span, which previously had been stalking the fish, were subjected to complete darkness. A check after 30 minutes and again after 1½ hours showed both animals in their usual resting positions in the tank, the scorpionfish alongside a rock and the octopus in a small *Tridacna* shell. Both animals operate very well in dim light. In nature, both are known to become most active at night, particularly at twilight. Complete darkness, however, might be expected to force animals dependent on vision to become inactive. The alteration of lighting conditions does not seem to confer any advantage to one or the other animal, but this factor requires more careful investigation.

DISCUSSION

The observations suggest a significant predator-prey interaction between scorpionfish and octopuses in nature. Octopuses can avoid the venomous spines by their exceptional agility, while other predators, such as fishes and marine mammals, are limited by structural rigidity.

The predator-prey relationship is size-specific; small octopuses occur in the diet of adult scorpionfish (Clarke, Flechsig, and Grigg, 1967: 1387; Fitch, 1960:71–72; Limbaugh, 1955:103; Taylor, 1963:90–93). We observed that a small individual, *Octopus bimaculatus,* with an arm spread of approximately 25 cm, was immediately ingested when introduced into an aquarium containing a scorpionfish of approximately 35 cm total length. Octopuses of more nearly equal size, however, excited alarm rather than the predatory interest of scorpionfish. Predation by the octopus may be most significant for the small juvenile scorpionfish. Even these appear to evade octopuses under most circumstances. The smallest scorpionfish that we observed, down to 5 cm total length, already had well-developed responses to octopuses. The adult fish may coexist with large octopuses without significant predation because of their comparable size and perhaps because of learning as a result of previous encounters.

It was the ability of the scorpionfish con-

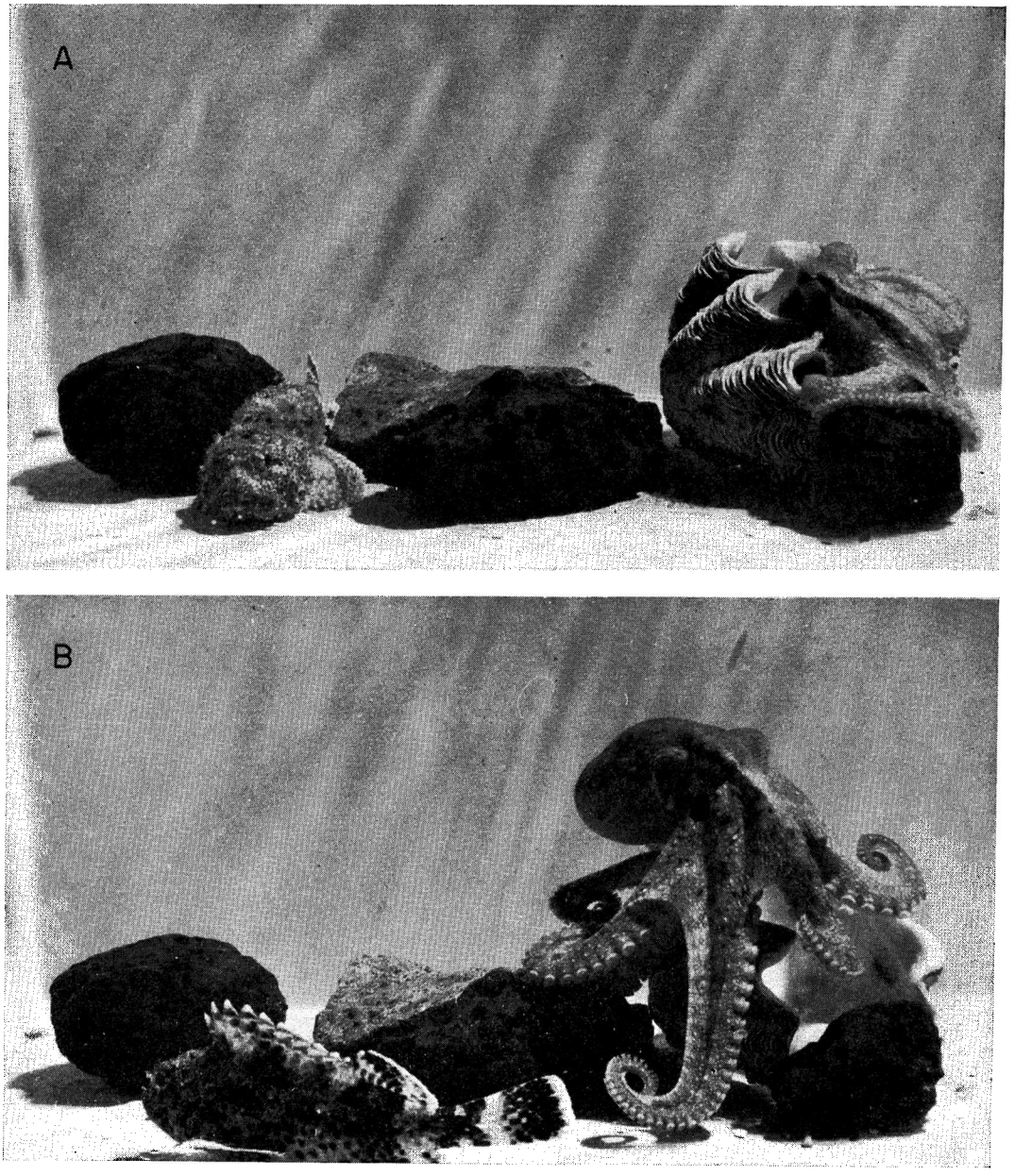

FIG. 2. Relative postures of a California scorpionfish (25 cm total length) and an octopus (50 cm arm spread) in a small aquarium tank. A, The animals in resting positions; B, the octopus stalking the scorpionfish.

sistently to escape capture by octopuses that allowed them to occupy the same habitat at surprisingly close quarters in the aquariums. This advantage was reduced when the animals were confined in small areas, as successful captures by octopuses demonstrated. Whether or not conditions occur in nature that give octopuses a similar advantage is not known. It appears that octopuses, by their attempts to capture scorpionfish, at least reduce the space available for the fish in certain habitats. The octopuses might limit the numbers of scorpionfish also by

competing for food—crustaceans are major items in the diets of both animals. Territorial fighting, however, would set the minimum spacing of octopuses, limiting the degree to which both factors exclude scorpionfish. The presence of octopuses in a habitat, therefore, probably would reduce the possible number of scorpionfish, but is not likely to exclude them completely.

ACKNOWLEDGMENTS

The authors are grateful for the generous cooperation of Mr. David C. Powell, Curator of Fishes, and his staff at Sea World, San Diego, California, and to many staff members at the Scripps Institution of Oceanography, particularly Mr. Donald W. Wilkie, Director of the Aquarium-Museum, and Mr. Robert Kiwala, Marine Collector. We thank Dr. Findlay E. Russell for his support in carrying out the research and for helpful comments on the manuscript.

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